Extrapleural, submuscular bars placed by bilateral thoracoscopy—a new improvement in modified Nuss funnel chest repair

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Abstract

Background: Thoracoscopic Nuss funnel chest repair still has a significant complication rate. Bar dislocation, pneumothorax, pleural effusions, and pericarditis seem to be caused mechanical irritation by the bar. We intended to reduce these problems by further technical modification of the Nuss technique.

Methods: Of 157 prospectively followed modified Nuss repairs, the last 57 patients had the bars placed in an extrapleural position and fixed by 10 to 14 pericostal sutures under bilateral thoracoscopy.

Results: Entirely, extrapleural bar position was feasible in 53 of 57 patients. Four patients had minor holes over one of the bars, predominantly on the left side of the thorax. Pleural effusions, pneumothorax, and pain were greatly reduced, so that we discontinued the so far routine use of bilateral pleural drainages.

Conclusions: Extrapleural bar position is feasible in more than 90% of modified Nuss repairs. It reduces pleural secretion and pain, and seems to reduce pneumothorax, pulmonary bar adhesions, and pericardial effusions. The technique is easy and safe, and reduced the incidence of most complications in this early experience of 57 adolescent patients, although no sportive restrictions were imposed at all.

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Thoracoscopic funnel chest repair is an established procedure, but classic Nuss repair has a considerable complication rate of 21% to 67% and reoperation rate of 29% [1-3]. Therefore, we introduced several modifications such as submuscular bar, multiple pericostal bar fixation, and bilateral thoracoscopy, which eliminated bar dislocation in our patients and reduced most other complications [4]. Still, pneumothorax (minor, 52%; major, 2.7%), pleural effusion, and pericarditis are the most severe complications [5]. We feel that they are associated to the parasternally intrapleural bar position. Moreover, we noted significant adhesions of the lungs to the bar in redo procedures when correcting Nuss repairs done elsewhere. Therefore, we devised a technique of placing the complete bar or bars...
into an entirely extrapleural position by bilateral thoracoscopy and have used this technique in the recent 57 patients.

1. Materials and methods

From April 2000 to May 2003, 157 adolescents and young adults (141 males and 16 females) with severe pectus excavatum (Haller index \[6\], 3.4-12.8) underwent Nuss repair with bilateral thoracoscopic assistance, all by the modified procedure we described \[4\]. All patients were symptomatic preoperatively; the complaints were shortness of breath on prolonged exertion, a noticeable heart beat even on slight exertion, and frequent bronchopulmonary infections. All the patients felt significantly impaired in sports and social activities.

The patients ranged in age from 12.3 to 42.1 years with an average of 17.4 ± 6.1 years (median, 16.4 years) and all patients were followed to date in a prospective observation study. Of 157 patients, 106 (62.7%) had thoracic asymmetry, 72 (45.9%) showed some degree of sternal rotation in addition, 62 (39.5%) got 2 bars inserted, and all patients had 2 stabilizers on the longer bar without steel wires. Six Nuss repairs were redos: 2 after Ravitch, 1 after Sulaama, and 3 after unsatisfactory standard Nuss; 2 were performed elsewhere. The aesthetic result was graded by a semiquantitative scale into excellent, good, fair, or unacceptable. The result was judged by 3 doctors and 3 nurses after bar removal, and the majority vote decided on the definitive grading.

For the modified Nuss repair, we used 2 high-definition television monitors and 30° 5-mm lens for bilateral thoracoscopy. In the recent 57 patients (redos excluded), the bar was placed in an entirely extrapleural position, and it is these 57 patients that this study is focused on. A 5-mm trocar was introduced into the lower third of the thorax bilaterally at the midaxillary line and at least 2 intercostal spaces caudally to the skin incision. No additional incision is used; we just took the standard exit holes of the bilateral submuscular suction drainages as port accesses. Then, the thorax was inflated by low-pressure carbon dioxide, and a nonpointed forceps was introduced through the marked right intercostal space under thoracoscopic vision until the tip of the forceps was visible below the pleural layer. Beginning at this point, a small extrapleural pouch was dissected similarly as in thoracoscopic pleurectomy (Fig. 1). Now, the clamp was advanced without piercing the pleura first along the intercostal space, and a wide extrapleural pouch was gradually dilated and extended toward the pleuropericardial fold, taking care to stay on the pleural side of the internal mammary vessels, that is, to have them not between dissector and pleura. Then, the forceps was replaced by the Lorenz dissector (Walter Lorenz Surgical, Jacksonville, Fla), which gradually lifted the pericardium from the sternum under indirect vision through the intact mediastinal pleura. Now, the right-sided dissector was held by an assistant, and a corresponding extrapleural tunnel was developed likewise from the left side.

Under thoracoscopic vision, the tip of the Lorenz dissector coming from the right became visible under the left mediastinal pleura (Fig. 1) and the left-sided forceps was advanced extrapleurally until the tips of the 2 instruments crossed (Fig. 2). Then, the left-sided forceps was gradually withdrawn while the dissector followed it through the left-sided extrapleural tunnel, maintaining continuous contact between both instruments until the dissector emerged at the
left intercostal entry point (Fig. 3). If several bars were introduced through the same skin incision, this procedure was repeated for each individual bar at several intercostal spaces, taking care to make the extrapleural pouch wide enough to allow for turning of all the bars. Two years ago, we have described the bar and stabilizer (Walter Lorenz Surgical) fixation technique by 10 to 14 pericostal braided polydioxanone sutures under thoracoscopic vision, keeping the lungs well out of the way by the residual pneumothorax [4]. On both sides, the extrapleural bar position was controlled by a second final-look thoracoscopy (Fig. 4).

2. Results

All operations were completed as Nuss repairs; there was no conversion to a Hegeman Willital [7], our standard open procedure, and in no case was any additional pre- or parasternal skin incision required. Extrapleural bar position is feasible in all patients, although our new method of extrapleural bar introduction has a certain learning curve. Although in 4 early patients minor pinpoint holes of the pleura were visible now and then, predominantly on the left side, in further 53 patients, we managed to keep the bars in an entirely extrapleural position regardless of whether 1 or 2 bars had been used; there was no patient with 3 bars in this recent series like in the previous one.

We and the nurses had the consistent impression that pain was significantly less and shorter in all patients with extrapleural bars. There was no secondary pneumothorax in these 57 patients, no case of late seroma, and no case of pericarditis, which supports our view that an extrapleural position of the bar or bars combined with our extremely solid multiple-point bar fixation reduces irritations of the parietal pleura, the visceral pleura, and the pericardium.

3. Discussion

Most publications have focused on the reduction of bar and stabilizer dislocation, probably because this was the preeminent unsolved issue so far in most centers [8]. Nuss et al [5] reported 8.8% (29/329) major bar shifts requiring repositioning in his recent series (neglecting the probably larger number of symptomatic minor bar shifts managed conservatively), whereas Hebra et al [8] had 9.2% (23/251) in his multicenter American Pediatric Surgical Association survey. We have reduced bar and stabilizer dislocation to zero [4] in 157 modified Nuss procedures and were searching for further improvements with regard to pleural effusion, pneumothorax, and pericardial effusion. Nuss et al [5] reported 54.7% pneumothorax (183/329), 2.7% requiring aspiration or chest tube. Because pleural effusion and pneumothorax are the most frequent complications, extrapleural bar position seems to reduce the irritation of the visceral pleura significantly.

A further issue is the incidence of pericarditis, which was 2.43% (8/329) in the Nuss et al [5] series and is 0.65% (1/157, ie, 1 early case) in our series. The pericardial irritation seems to have 2 causes: one is latent instability and minor bar shifts or tilts, which we eliminated by pericostal fixation [4], particularly by the most medial parasternal sutures; and the second is that pericardium is somewhat fixed and approximated to the sternum by the mediastinal
pleura at the bar entry points into the retrosternal space. Conversely, because of the wide mobilization of pericardium and ventral parietal pleura for passage of extrapleural bars, the pericardium is allowed to fall further back from the sternum, which increases the sternopericardial distance.

Finally, we were alarmed by ventilatory restriction, significant adhesions of both lungs to the bar, and trapping of lower lobes discovered during redo Nuss after 3 Nuss repairs (2 elsewhere) and 3 Ravitch/Sulaama repairs. In these 6 redo procedures, we required extensive bilateral pulmonary adhesiolysis before Nuss bar placement. Probably, no sizeable number of patients had bilateral rethoracoscopcy after a Nuss procedure so far, and no information on incidence and degree of adhesions to the bar is published. In our limited experience, significant adhesions were present in all redo procedures after previous Nuss repairs. With an extrapleural bar, we expect less or even no adhesions of the lung, so this in itself would justify extrapleural bar position. Moreover, it is easier to keep pericostal sutures extrapleural as well (Fig. 4) when the pleura has already been detached from the thoracic wall.

Because we use bilateral thoracoscopy with 1 alternate camera or 2 cameras in all Nuss procedures right from the beginning, extrapleural bar placement does not require any additional setup. Cardiothoracic surgeons practicing the Nuss procedure have tried to solve the problem by sheathing the bar by a silicone sleeve. Jacobs et al [9] reported 31 patients (4.4-31 years; mean, 14.5 years) where he put the bar into a “protective flat silastic drain” with 5 pneumothoraces, 2 subcutaneous seromas, and a bilateral pleural effusion requiring drainage. However, rather than introducing a second foreign body into the thoracic cavity, we favor the natural extrapleural tunnel as a more physiological way of separating the bars from the pleural cavity; similarly as in wandering spleens, we use a retroperitoneal pocket for laparoscopic splenopexy, which rapidly contracts firmly around the spleen [10].

The impressive patient satisfaction with extrapleural bars may be understood by the fact that a considerable part of the experienced thoracic pain seems to be mediated via the pleura, as we know from pleural puncture, where the pleura itself is the most irritable part of the procedure. So, it may be a great advantage that the bars no longer cross the pleural barrier and do not irritate the entrance and exit holes. We had no opportunity to do a late rethoracoscopy in these extrapleural patients except the bilateral intraoperative final-look thoracoscopy at the end of the procedure (Fig. 4), but we expect little or no adhesions after the introduction of extrapleural bar position, which will facilitate redo surgery. Similar to the retroperitoneal accesses in endoscopic renal and adrenal surgery, extrapleural access has stood the test of time in esophageal atresia surgery, where the lung is treated more gently by extrapleural access and the same advantages are likely to be found in extrapleurally managed Nuss cases.

With transpleural bars, we experienced a case of massive bilateral serothorax, right pneumoserothorax, and trapped lower lobe, which required early bar removal and thoracoscopic decortication. In bar infections, the process will be separated from both pleural cavities.

In summary, the feasibility of truly extrapleural placement of 1 or multiple bars has been proven for a significant number of patients.

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References